

CLAIMS:

1. A method of selective absorption of hydrogen sulfide relative to carbon dioxide from a supply gas stream comprising:

providing a supply gas stream containing at least a product gas, hydrogen sulfide and carbon dioxide;

providing an absorbent which absorbs both hydrogen sulfide and carbon dioxide while exhibiting preferential affinity for hydrogen sulfide relative to carbon dioxide;

generating a stream of the absorbent which moves from a lean condition in countercurrent flow over a series of contact stages to a stream of the supply gas so as to contact the absorbent with the supply gas stream so as to absorb at least partly the hydrogen sulfide and the carbon dioxide to form a rich absorbent while generating a stream of sweetened product gas which contains levels of hydrogen sulfide and carbon dioxide below a predetermined maximum allowable value;

passing the rich absorbent through a regeneration process which strips substantially all of the hydrogen sulfide and carbon dioxide from the rich absorbent returning the absorbent to the lean condition for said stream while generating a stream of the hydrogen sulfide and carbon dioxide;

wherein the absorption of the hydrogen sulfide and carbon dioxide by the absorbent is carried out in two steps in which:

in a first operation the absorbent in lean condition is contacted with the supply gas stream;

and in a second operation the selectivity for hydrogen sulfide relative to carbon dioxide is enhanced by contacting the rich absorbent leaving the first operation with a second gas which has a higher ratio of hydrogen sulfide relative to carbon dioxide than the supply gas stream so as to cause the already rich absorbent to become even more heavily loaded with hydrogen sulfide and carbon dioxide, but because of the high ratio of the second gas, the increased loading is preferentially in favor of hydrogen sulfide.

2. The method according to claim 1 wherein the source of the second gas is the stream of the hydrogen sulfide and carbon dioxide, a portion of which is recycled back to the second operation, where the stream of the hydrogen sulfide and carbon dioxide contains approximately the same ratio as existed in the rich absorbent after the second operation. .

3. The method according to claim 1 wherein the contact with the second gas in the second operation occurs counter currently over a series of contact stages.

4. The method according to claim 1 wherein the first and second operations take place in the same countercurrent absorption column which operates throughout at substantially the same pressure.

5. The method according to claim 1 wherein lean amine entering at the top of the upper section of the column comes in contact with sour gas containing both  $H_2S$  and  $CO_2$  which enters the column at an intermediate stage in the mid section of the absorber at the point where the first operation interfaces with the second operation., wherein the first operation occurs in the upper section of the

column and the second operation occurs in the lower section such that the combined actions of the first and second absorption operations will attain an internal balance in which the rich amine leaving the base of the column will be enriched in  $\text{H}_2\text{S}$ , while the  $\text{CO}_2$  thus excluded from the rich amine solution will exit from the top of the column along with the sweetened product gas from which the  $\text{H}_2\text{S}$  has been removed.

6. The method according to claim 1 wherein there is provided a single feed of the lean absorbent at a top of the first operation.

7. The method according to claim 1 wherein there are provided a plurality of feeds of the lean absorbent at different positions through the first and second operations.

8. The method according to claim 1 wherein the first and second operations take place in at least two different absorber towers operating at different pressures.

9. The method according to claim 8 wherein the first operation takes place substantially wholly in the first tower which operates at a higher pressure than the second operation in the second tower.

10. The method according to claim 8 wherein the second absorber tower is arranged to control the amount of carbon dioxide in the sweetened product gas from the first tower by taking greater advantage of the natural preference of the absorbent for hydrogen sulfide to effect "slipping" in which a portion of the carbon dioxide is permitted to exit with the sweetened product gas.

11. The method according to claim 8 including contacting the gas in the upper section of the second tower with a stream of the absorbent in lean condition

that is fed at a top stage of the second tower such that the lean absorbent, having a very low residual hydrogen sulfide content, is capable of removing essentially all of the hydrogen sulfide from the acid gas stream, producing an overhead carbon dioxide vapour that is almost entirely free of hydrogen sulfide.

12. The method according to claim 8 including interposing a flash drum in the feed stream of rich upstream absorbent where the reduced pressure of the flash drum allows light dissolved vapors to evolve and be removed from the absorbent.

13. The method according to claim 8 wherein the first and second operations in the first and second towers are arranged such that the partially loaded absorbent from the upper stages of the second absorber combine with the rich absorbent from the first tower and flow downward to the lower stages of the second tower and wherein the overall operation of the first and of the second towers reaches an internal balance in which the rich absorbent leaving the bottom of the second tower is enriched in hydrogen sulfide, while the carbon dioxide thus excluded from the absorbent exits from the top of the second tower as a water saturated carbon dioxide stream essentially free of hydrogen sulfide.

14. The method according to claim 8 including providing a plurality of lean absorbent feed points on both the first and second towers in order to optimize selectivity of the amine for hydrogen sulfide under varying operating conditions.

15. The method according to claim 8 wherein the source of the second gas stream is a portion of the hydrogen sulfide enriched acid gas overhead from the absorbent regenerator, which is recycled back to the second tower.

16. The method according to claim 8 wherein there is provided a first and a second tower wherein the acid gas product from said regenerator and a portion of the rich amine from the first absorber tower are sent to a third absorber tower and rich amine from the base of the third absorber tower is sent to a second regenerator which produces an overhead acid gas in which the  $H_2S$  is more concentrated than the acid gas from the first regenerator and wherein a portion of the enriched acid gas from the second regenerator is recycled to the base of the third absorber tower where it is contacted with a side stream of rich amine from the first absorber tower, which enters at a mid section of the third absorber tower, and by lean amine that enters at a top of the third absorber tower, producing an overhead stream of essentially pure  $CO_2$  and water vapor from the third absorber tower. .

17. The method according to claim 16 comprising a first effect followed by a second effect which by using multiple stages of absorption and regeneration is able to produce an acid gas that is progressively richer in  $H_2S$  wherein the staging process is continued to a third effect or more by adding additional stages of absorption and regeneration and wherein each additional stage of absorption receives acid gas and rich amine from preceding effects and produces a stream of  $CO_2$  and rich amine which when regenerated produces an enriched acid gas, a portion of which is recycled back to its absorber.

18. The method according to claim 8 wherein the lean amine for the first absorber tower is drawn from a stage in the regeneration process above a reboiler while the lean amine for the second absorber tower is drawn from the bottom of the regenerator process in order to meet the differing tolerances of the first and

second absorber towers for residual acid gas in the lean amine.

19. The method according to claim 1 wherein it is desired to maximize recovery of CO<sub>2</sub> as a by-product by minimizing slipping CO<sub>2</sub> in a first absorber tower by adjusting operating conditions, solution concentration, circulation rate, type of contacting device and stages of contact so as to increase CO<sub>2</sub> absorption in the first absorber tower thus enabling increased CO<sub>2</sub> production in subsequent absorber towers.

20. The method according to claim 1 in which side coolers are used on absorbers to cool the process and to reduce the rate of the CO<sub>2</sub> reaction with amine.

21. A method of selective absorption of hydrogen sulfide relative to carbon dioxide from a supply gas stream comprising:

providing a supply gas stream containing at least a product gas, hydrogen sulfide and carbon dioxide;

providing an absorbent which absorbs both hydrogen sulfide and carbon dioxide while exhibiting preferential affinity for hydrogen sulfide relative to carbon dioxide;

generating a stream of the absorbent which moves from a lean condition in countercurrent flow over a series of contact stages to a stream of the supply gas so as to contact the absorbent with the supply gas stream so as to absorb at least partly the hydrogen sulfide and the carbon dioxide to form a rich absorbent while generating a stream of sweetened product gas which contains levels of hydrogen sulfide and carbon dioxide below a predetermined maximum allowable

value;

passing the rich absorbent through a regeneration process which strips substantially all of the hydrogen sulfide and carbon dioxide from the rich absorbent returning the absorbent to the lean condition for said stream while generating a stream of the hydrogen sulfide and carbon dioxide;

wherein the absorption of the hydrogen sulfide and carbon dioxide by the absorbent is carried out in two steps in which:

in a first operation the absorbent in lean condition is contacted with the supply gas stream;

and in a second operation the selectivity for hydrogen sulfide relative to carbon dioxide is enhanced by contacting the rich absorbent leaving the first operation with a second gas which has a higher ratio of hydrogen sulfide relative to carbon dioxide than the supply gas stream so as to cause the already rich absorbent to become even more heavily loaded with hydrogen sulfide and carbon dioxide, but because of the high ratio of the second gas, the increased loading is preferentially in favor of hydrogen sulfide;

wherein the first and second operations take place in first and second different absorber towers where the second absorber tower operates at a pressure lower than the first and lower than the regeneration process and wherein there is provided a liquid pump for pressurizing the absorbent from the second absorber tower for supply to the regeneration process.